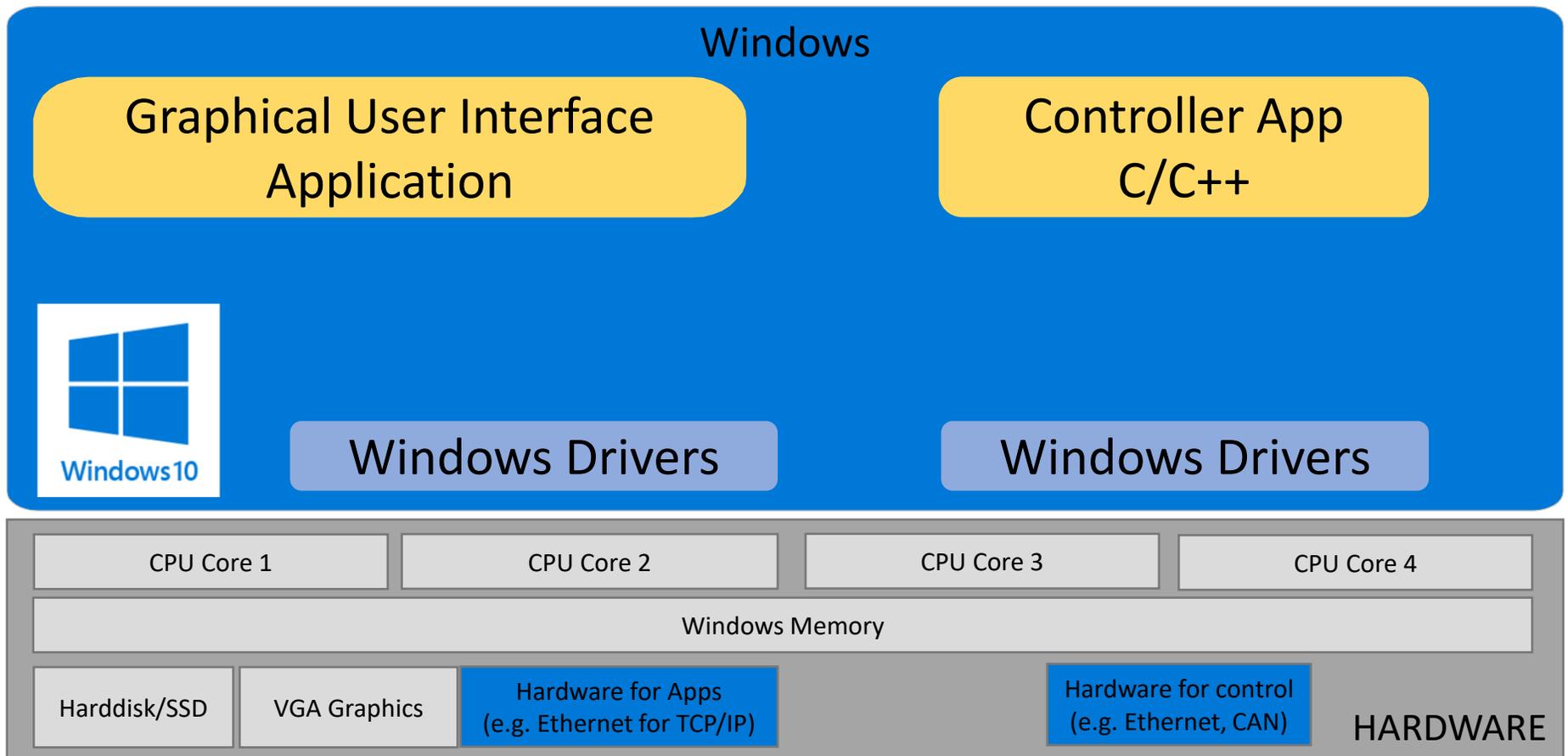


LxWin[®]

Windows Real-time Extension

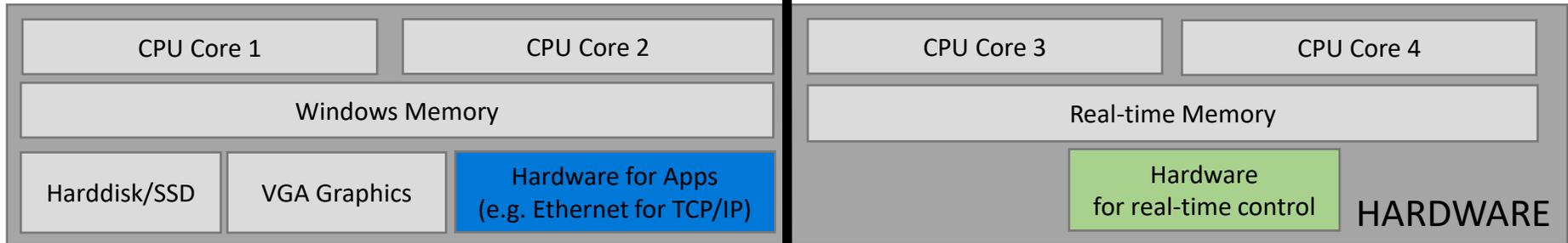
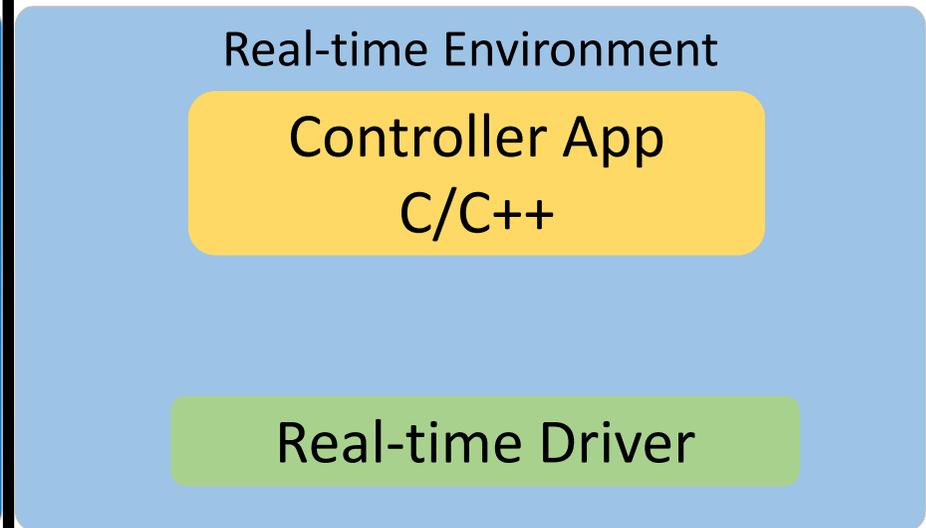
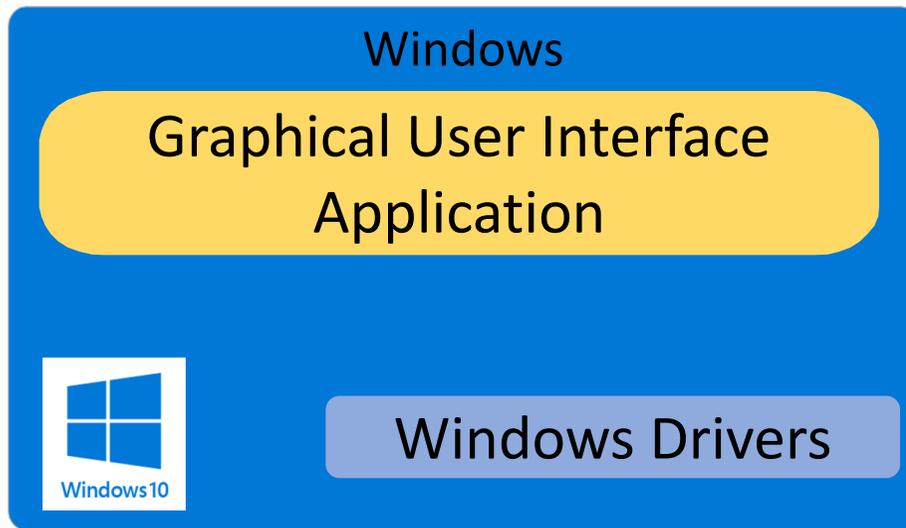
August 2020

Design without Real-time Environment



- Controller App and Drivers run on Windows: **no determinism!**

Design with Real-time Environment



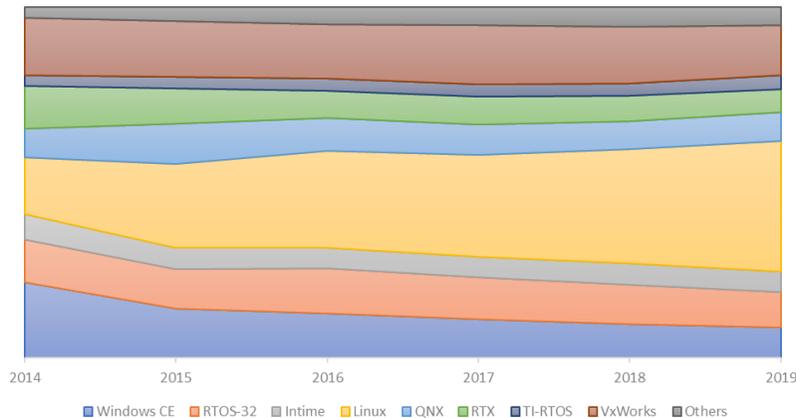
- Partitioning: split hardware in Real-time and Non-Real-time part
- Real-time applications must not use any Windows software components or Windows drivers
- Controller App and Real-time drivers run in Real-time Environment: **deterministic!**

LxWin[®]

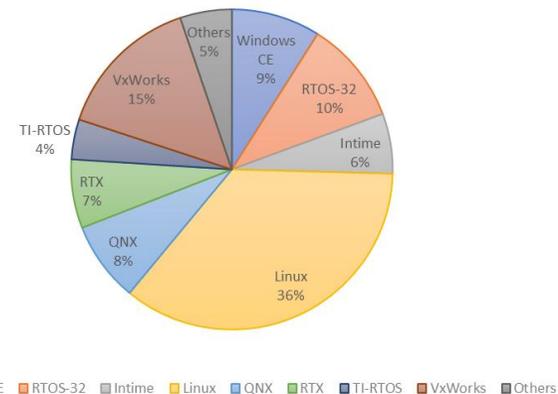
Real-time Linux

- **acontis approach**
 - Hypervisor based solution: better isolation, more robust
 - no proprietary real-time environment
- **The most popular real-time OS: RT-Linux**
 - Used by most customers all over the world

acontis EtherCAT Master Real-time OS Adoption over Time



acontis EtherCAT Master Real-time OS Adoption

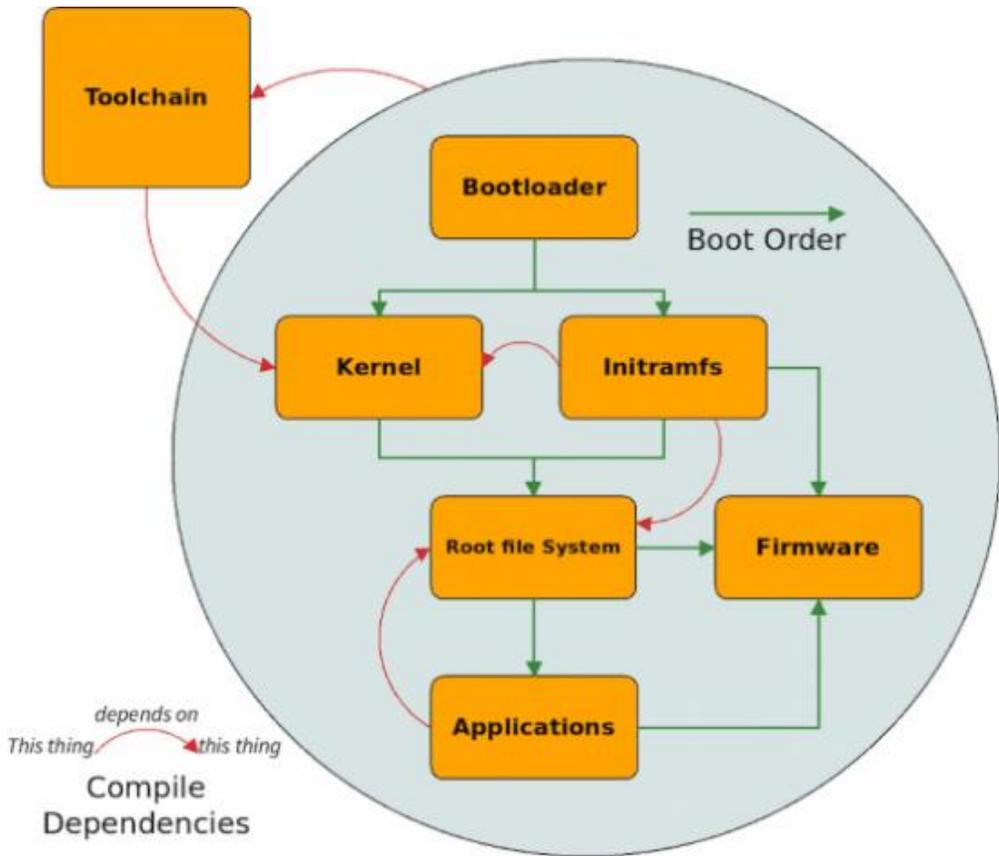


- **RT-Linux today: the most powerful real-time OS available (API richness, OS capabilities, ...)**
- **Thousands of drivers, hundreds of third-party products available**

- RT Preempt Patch
 - Adds hard real-time to Linux, proven in thousands of industrial applications
 - LxWin: ready to use headless real-time image included
 - Customer does not need to be a Linux expert
 - Real-time capabilities verified by acontis
 - Customer can concentrate on the application part
- Posix support
 - Standard API for real-time and multitasking programming (e.g. threads, semaphores, ...)
- Win32 support
 - acontis provides wrappers and code snippets for porting purposes
- Scalable Solutions can be built
 - Level 1: Embedded Controller without GUI: use native, embedded Linux
 - Level 2: Embedded Controller with GUI: use native Linux with GUI (e.g. Qt)
 - Level 3: High End Controller with powerful Windows GUI: use LxWin

- Hard real-time performance (extremely short latencies).
- 64 Bit and 32 Bit support
- Symmetric multiprocessing (utilize multiple cores)
- Powerful OS
 - Separate applications from Kernel
 - Powerful communication means
 - Posix compliant
 - Great development tools

Linux Architecture



- **Bootloader**
 - Most popular in most distributions: grub
 - LxWin: Uploader tool
- **Kernel**
 - Linux Kernel + essential built-in drivers
 - LxWin: Created using Yocto
 - LxWin: adjusted to support acontis Hypervisor
 - Goal: small kernel for typical customer applications (e.g. no drivers for hard disk etc.)
- **Initramfs**
 - RAM filesystem with additional driver modules, tools and some applications (e.g. busybox with shell)
 - LxWin: Created using Yocto
 - Goal: as small as possible
- **Root file system**
 - Typically located on a hard disk or SSD
 - Contains all driver modules, applications etc.
 - LxWin: identical to the Initramfs
- **Firmware**
 - For specific hardware to update internal firmware
 - LxWin: currently not used

- **Applications**
 - typically stored in the root filesystem (on the hard disk)
 - LxWin: mounted into Linux at /mnt/rfiles or part of the initramfs
- **Toolchain**
 - Windows development host: Provided by acontis (gnu toolchain). Created using crosstool-NG.
 - Linux development host: Standard GNU toolchain can be used.
 - Remote Debugging using gdb on the debug host and the gdbserver running in the LxWin image. Connection using ssh over TCP/IP (virtual network)

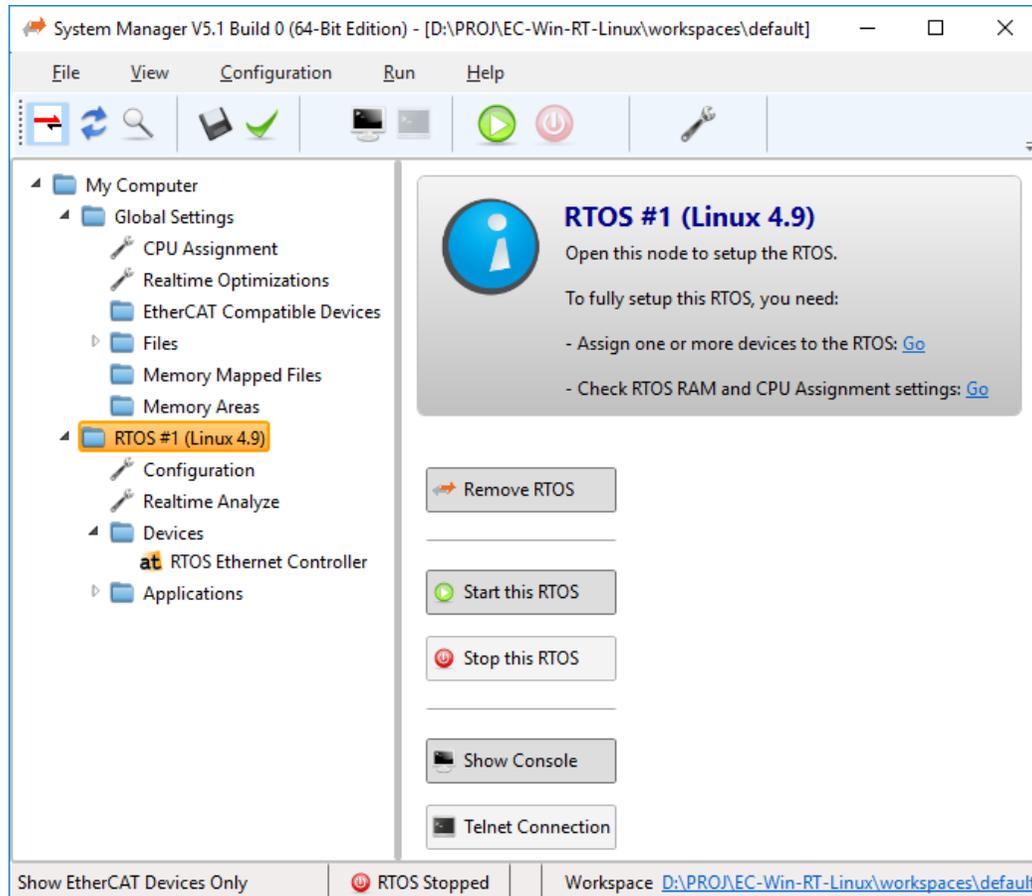


System Manager Tool

Configuration and Development Management Console

System Manager Tool: Management Console

GUI for configuration and runtime management



- Hardware Partitioning
- System Configuration (e.g. RAM size for Linux)
- Launch Panel (e.g. start/stop Linux)

System Manager V5.1 Build 0 (64-Bit Edition) - [D:\PROJ\EC-Win-RT-Linux\workspaces\default]

File View Configuration Run Help

My Computer

- Global Settings
 - CPU Assignment**
 - Realtime Optimizations
 - EtherCAT Compatible Devices
- Files
- Memory Mapped Files
- Memory Areas
- RTOS #1 (Linux 4.9)
 - Configuration
 - Realtime Analyze
- Devices
 - at RTOS Ethernet Controller
- Applications

CPU Assignment

Assign Operating Systems to the CPU's:

CPU#	Windows 10	Linux 4.9
CPU1	<input checked="" type="checkbox"/>	<input type="checkbox"/>
CPU2	<input checked="" type="checkbox"/>	<input type="checkbox"/>
CPU3	<input checked="" type="checkbox"/>	<input type="checkbox"/>
CPU4	<input type="checkbox"/>	<input checked="" type="checkbox"/>

CPU assignment is valid

Reset Recommended

Recommended:
The recommended CPU configuration for this system will be created/ restored. **After saving the changes a reboot maybe required!**

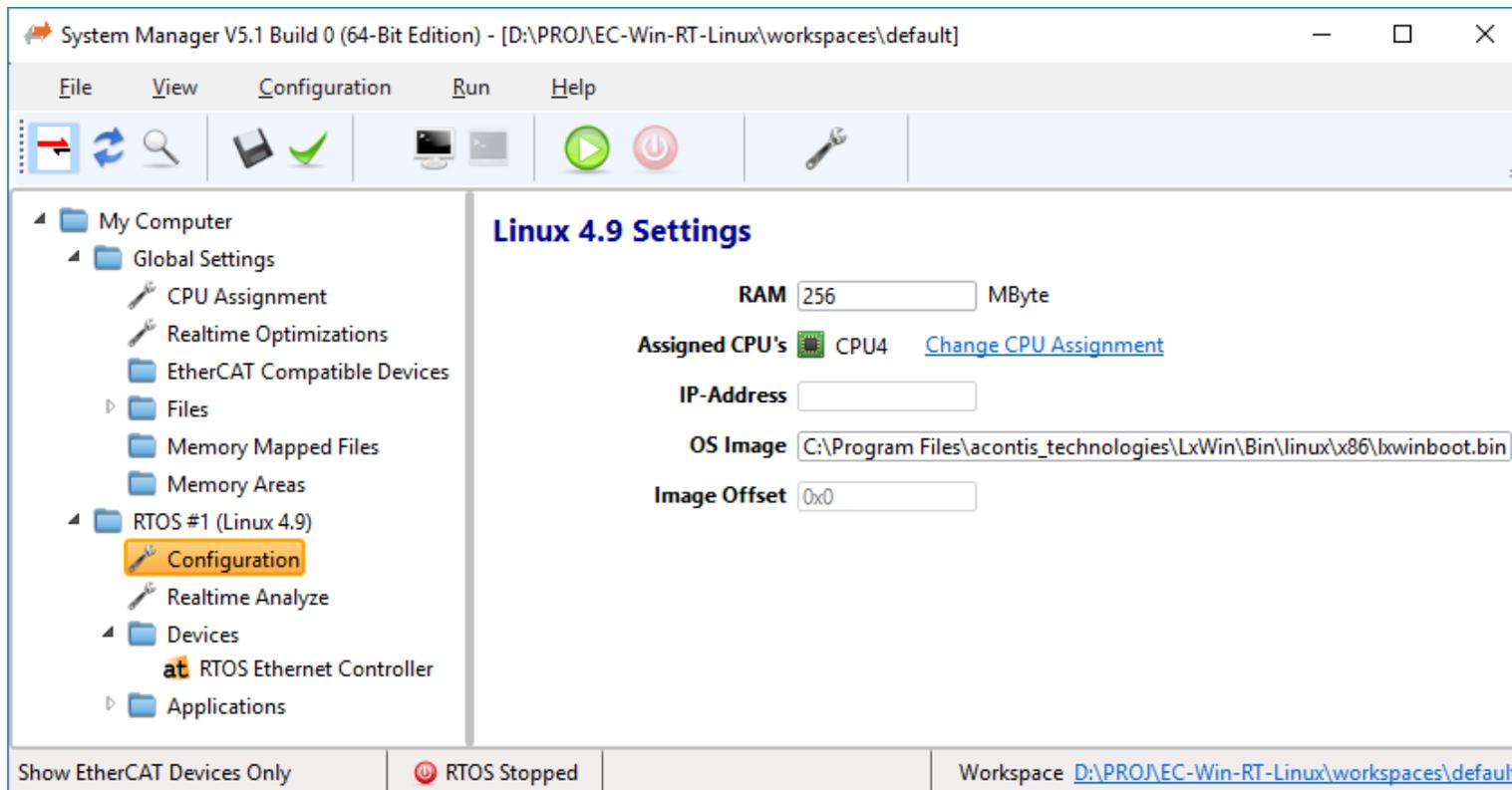
Reset:
All changes are reverted back. Exclusively reserved CPU(s) for the RTOS(es) will give(n) back to Windows. **After saving the changes a reboot maybe required!**

Show EtherCAT Devices Only | RTOS Stopped | Workspace D:\PROJ\EC-Win-RT-Linux\workspaces\default

- CPU Assignment
 - Select number of CPUs to be used by Windows
 - Select CPU(s) to be used by Linux

- RAM Assignment

- Set RAM size for Linux, will be allocated at early boot stage, up to about 3 GByte
- Memory is invisible for Windows (and vice versa)!



System Manager Tool: Hardware Partitioning



The screenshot shows the System Manager interface with the following details:

- Left Panel:** A tree view under 'My Computer' > 'Global Settings' > 'Devices' > 'Network adapters'. The 'Realtek PCIe GBE Family Controller' is selected and highlighted in orange.
- Right Panel:** Displays the configuration for the 'Realtek PCIe GBE Family Controller'. It includes the device name, VendorId (10EC), DeviceId (8168), and Bus information (Bus 03, Dev 00, Fct 00). It also notes that 'Interrupt is enabled (18)'. Three buttons are available: 'Assign to RTOS (Legacy Interrupt Enabled)', 'Assign to RTOS (MSI Enabled)', and 'Assign to RTOS (Interrupt Disabled)'. A 'Properties' button is also present.
- Legacy Interrupt Usage Table:** A table listing interrupt numbers and their corresponding devices. The entry for interrupt 18, 'Realtek PCIe GBE Family Controller', is highlighted in green.
- Bottom Bar:** Shows 'Show All Devices', 'RTOS Stopped' status, and the current workspace path: 'C:\Users\szf\AppData\Roaming\acontis technologies\workspaces\default2'.

- Device Assignment
 - Select Device currently controlled by Windows
 - Assign Device to Linux

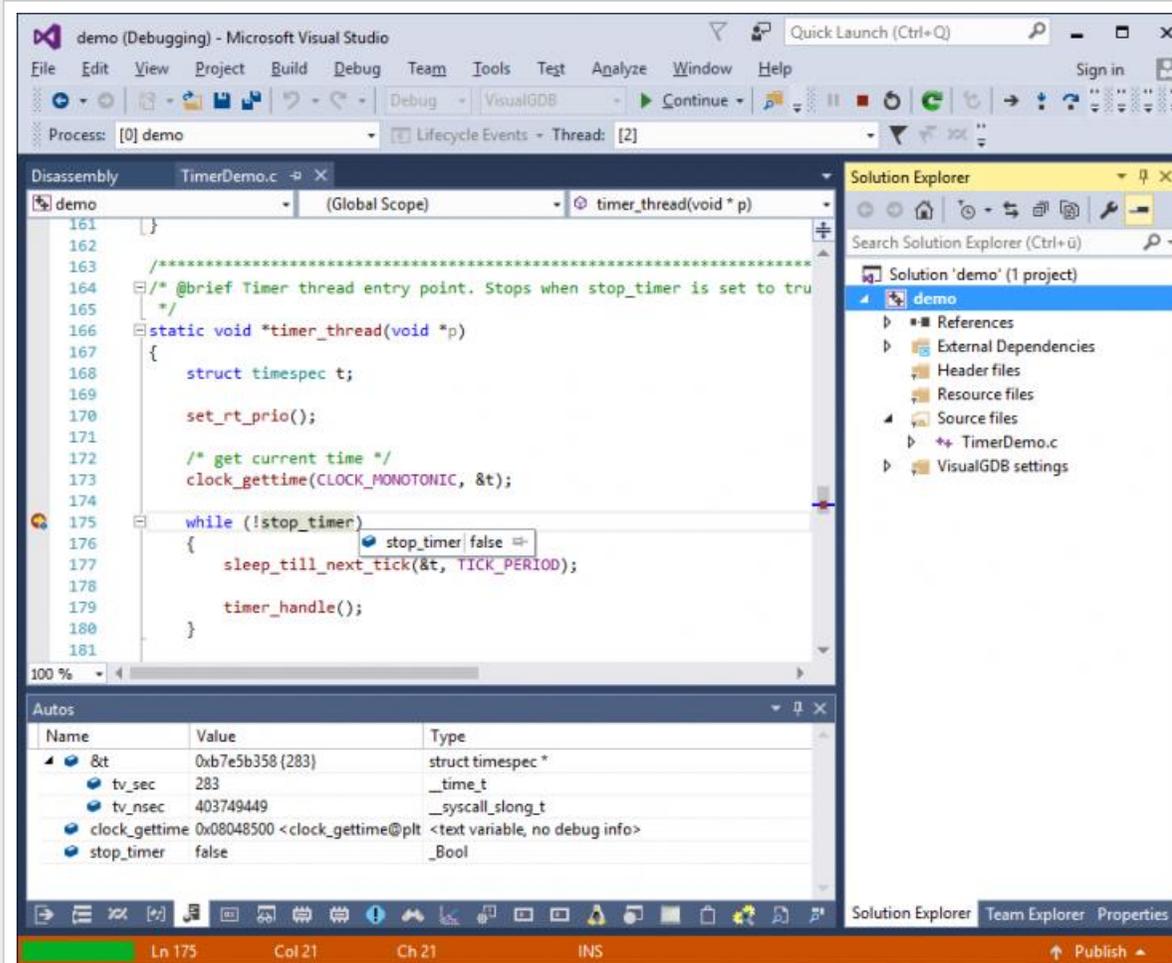
System Manager Tool: Hardware Partitioning

Device ready to use for Linux

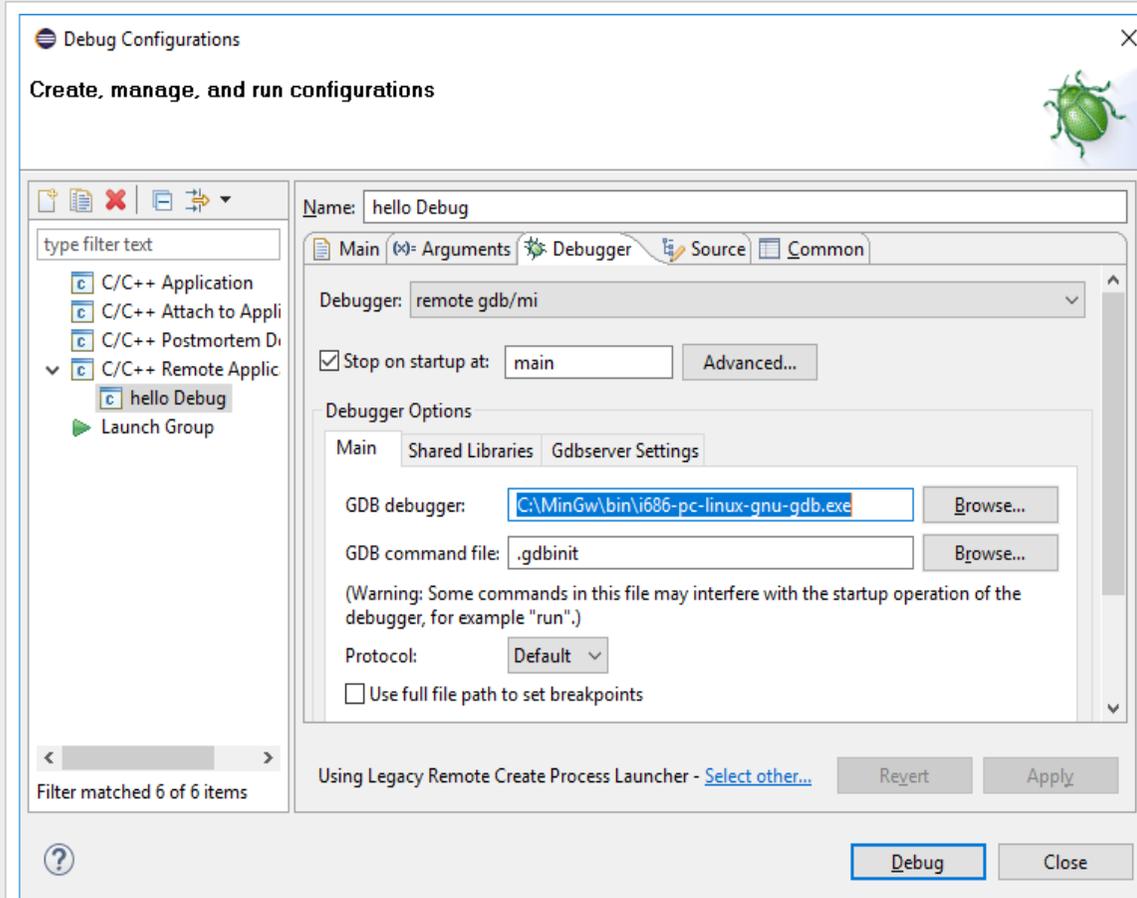
The screenshot shows the System Manager V4.0 Build 99 (64-Bit Edition) interface. The window title is "System Manager V4.0 Build 99 (64-Bit Edition) - [C:\Users\szf\AppData\Roaming\acontis technologies\workspaces\default2]". The menu bar includes File, View, Configuration, Run, and Help. The toolbar contains icons for navigation, search, and device management. The left sidebar shows a tree view under "My Computer" with folders for "Global Settings", "Files", "Memory Mapped Files", "Memory Areas", "RTOS #1 (Linux 4.4)", and "Devices". The "Devices" folder is expanded, and "at RTOS Realtek 8169/8168/8111 compatible PCI card" is selected. The main pane displays the device's properties: "RTOS Realtek 8169/8168/8111 compatible PCI card", "VendorId 10EC DeviceId 8168 (Bus 03 Dev 00 Fct 00)", and "Interrupt is enabled (MSI)". Below the properties are several buttons: "Assign to Windows", "IRQ Property: Legacy", "IRQ Property: MSI", "IRQ Property: None", "Rename Device", and "Properties". The status bar at the bottom shows "Show EtherCAT Devices Only", "RTOS Stopped", and "Workspace C:\Users\szf\AppData\Roaming\acontis technologies\workspaces\default2".

LxWin[®]

SOFTWARE Development



- Visual Studio
 - For Windows applications
 - For RT-Linux real-time applications
- Powerful VisualGDB plugin for real-time application development
- Project Wizards
 - Automatically Create new real-time applications
- Application Debugging
 - As convenient as debugging a regular Windows application



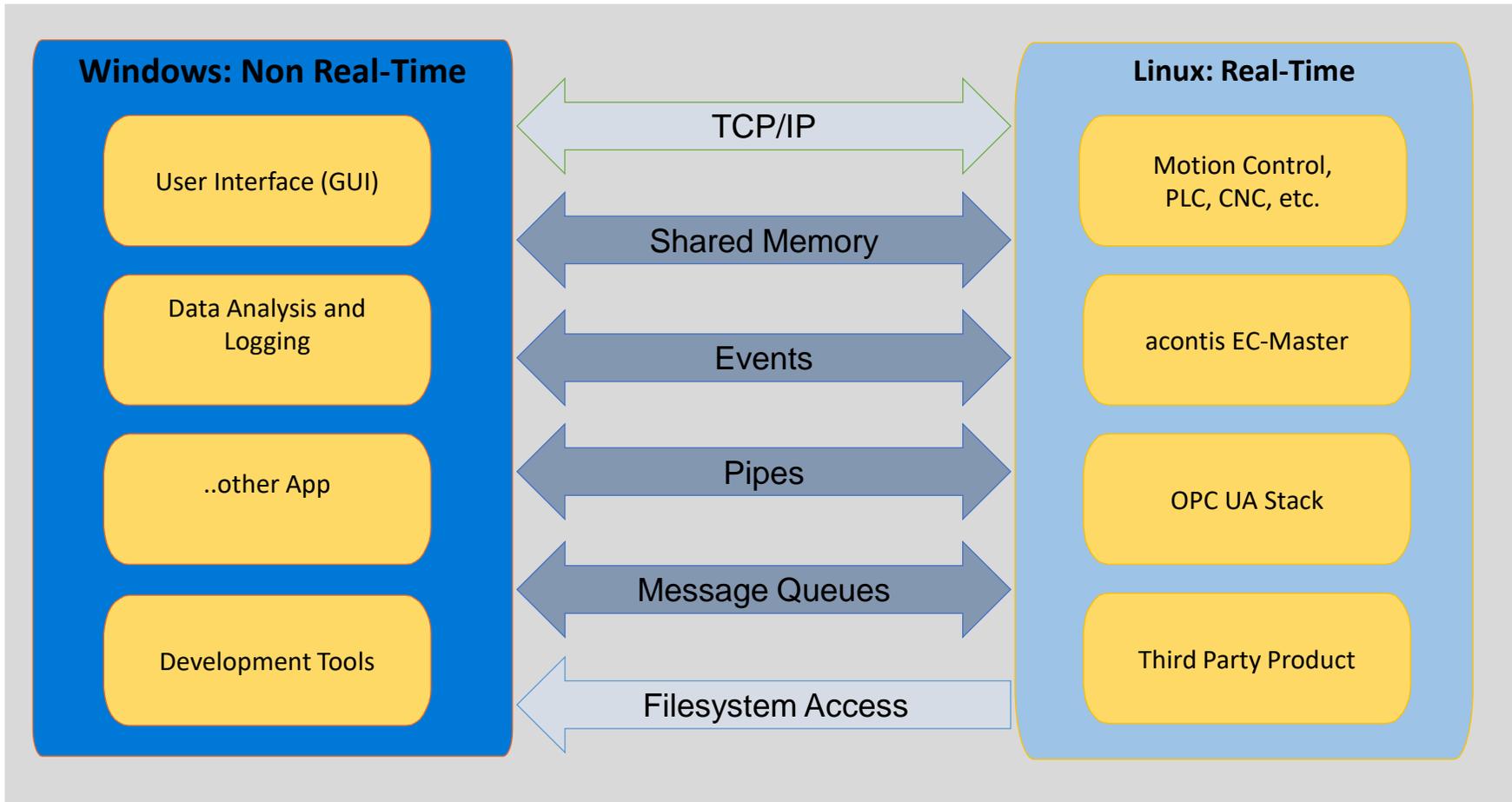
- Free and open source
- Standard IDE on Linux hosts
- Also available for Windows



Communication

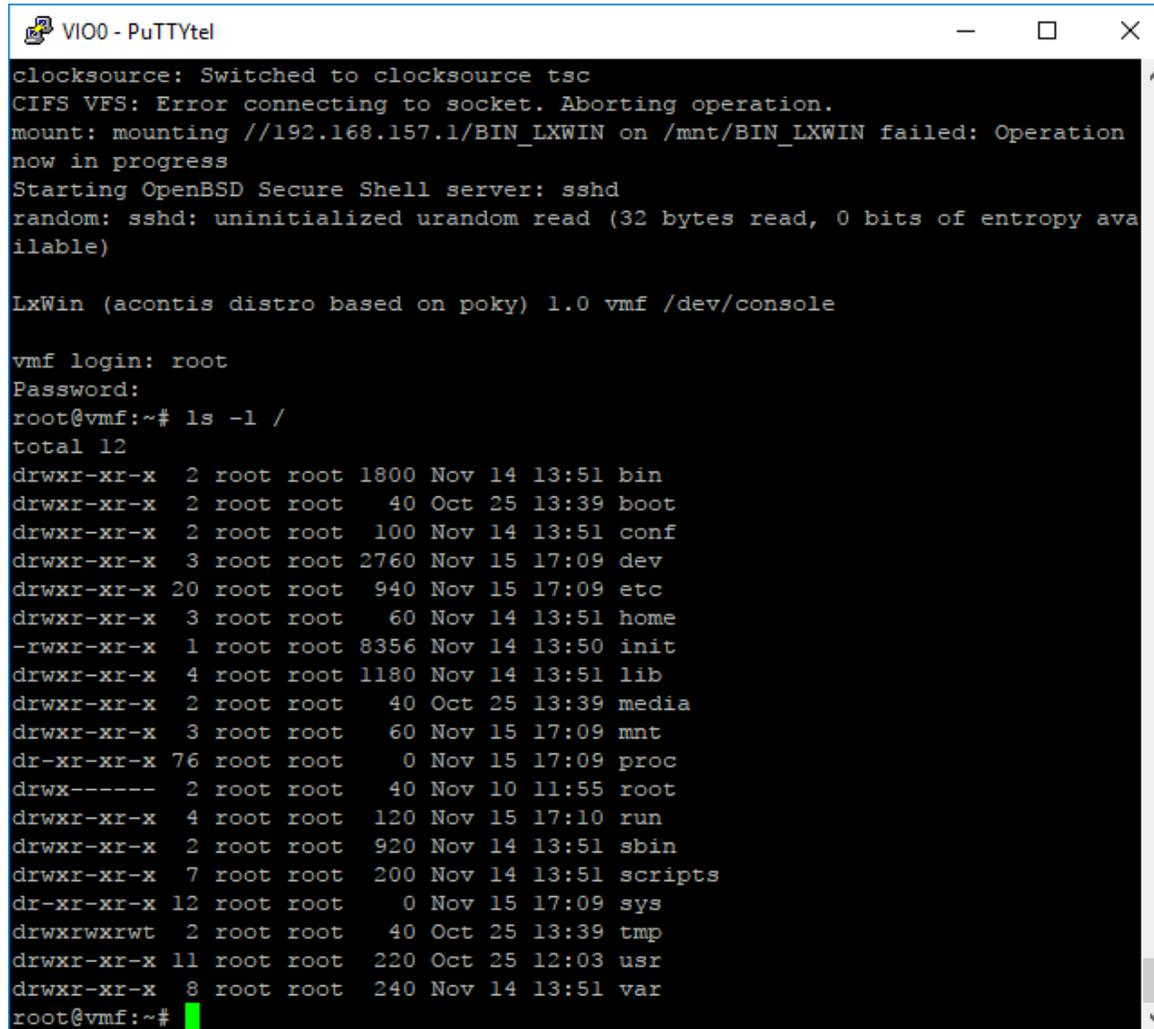
Data and information exchange between Windows and Linux

Windows and Linux interaction



Virtual Console

- Can be used for Linux Shell



```
clocksource: Switched to clocksource tsc
CIFS VFS: Error connecting to socket. Aborting operation.
mount: mounting //192.168.157.1/BIN_LXWIN on /mnt/BIN_LXWIN failed: Operation
now in progress
Starting OpenBSD Secure Shell server: sshd
random: sshd: uninitialized urandom read (32 bytes read, 0 bits of entropy ava
ilable)

LxWin (acontis distro based on poky) 1.0 vmf /dev/console

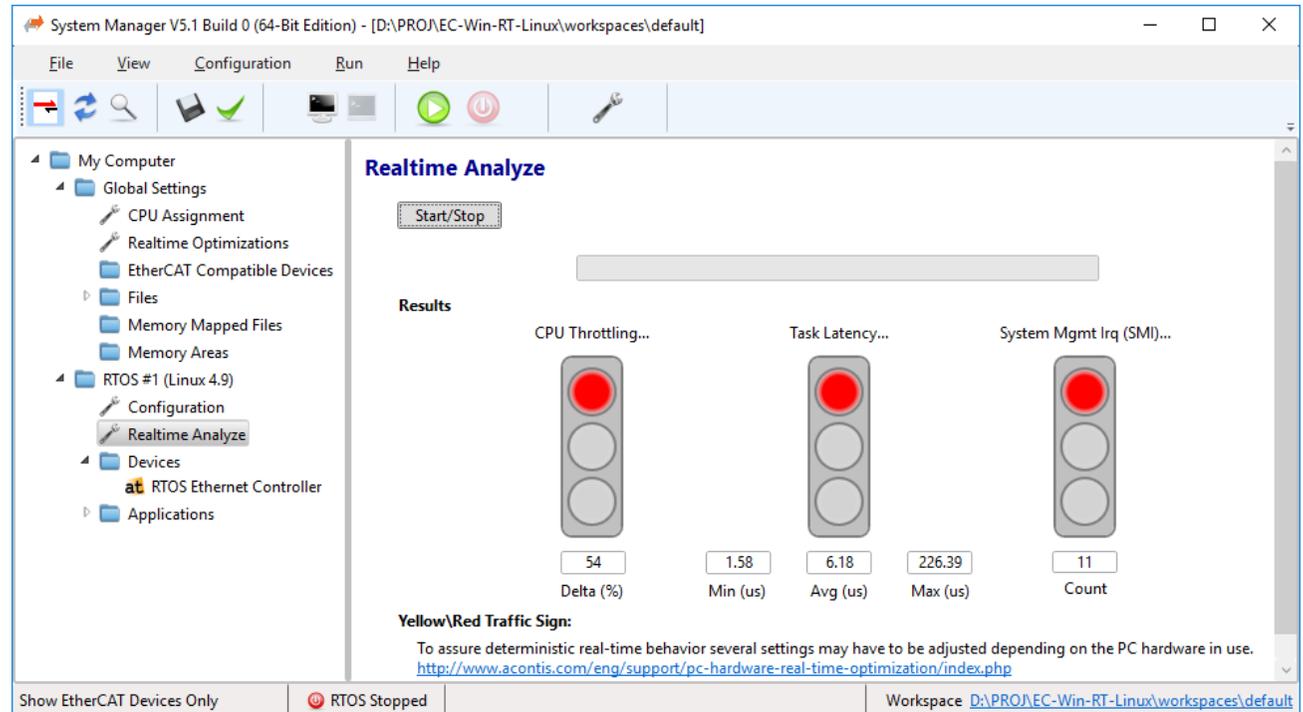
vmf login: root
Password:
root@vmf:~# ls -l /
total 12
drwxr-xr-x  2 root root 1800 Nov 14 13:51 bin
drwxr-xr-x  2 root root  40 Oct 25 13:39 boot
drwxr-xr-x  2 root root 100 Nov 14 13:51 conf
drwxr-xr-x  3 root root 2760 Nov 15 17:09 dev
drwxr-xr-x 20 root root  940 Nov 15 17:09 etc
drwxr-xr-x  3 root root  60 Nov 14 13:51 home
-rwxr-xr-x  1 root root 8356 Nov 14 13:50 init
drwxr-xr-x  4 root root 1180 Nov 14 13:51 lib
drwxr-xr-x  2 root root  40 Oct 25 13:39 media
drwxr-xr-x  3 root root  60 Nov 15 17:09 mnt
dr-xr-xr-x 76 root root   0 Nov 15 17:09 proc
drwx----- 2 root root  40 Nov 10 11:55 root
drwxr-xr-x  4 root root 120 Nov 15 17:10 run
drwxr-xr-x  2 root root 920 Nov 14 13:51/sbin
drwxr-xr-x  7 root root 200 Nov 14 13:51/scripts
dr-xr-xr-x 12 root root   0 Nov 15 17:09/sys
drwxrwxrwt  2 root root  40 Oct 25 13:39/tmp
drwxr-xr-x 11 root root 220 Oct 25 12:03/usr
drwxr-xr-x  8 root root 240 Nov 14 13:51/var
root@vmf:~#
```

LxWin[®]

Real-time on Windows

Real-time analysis and optimization

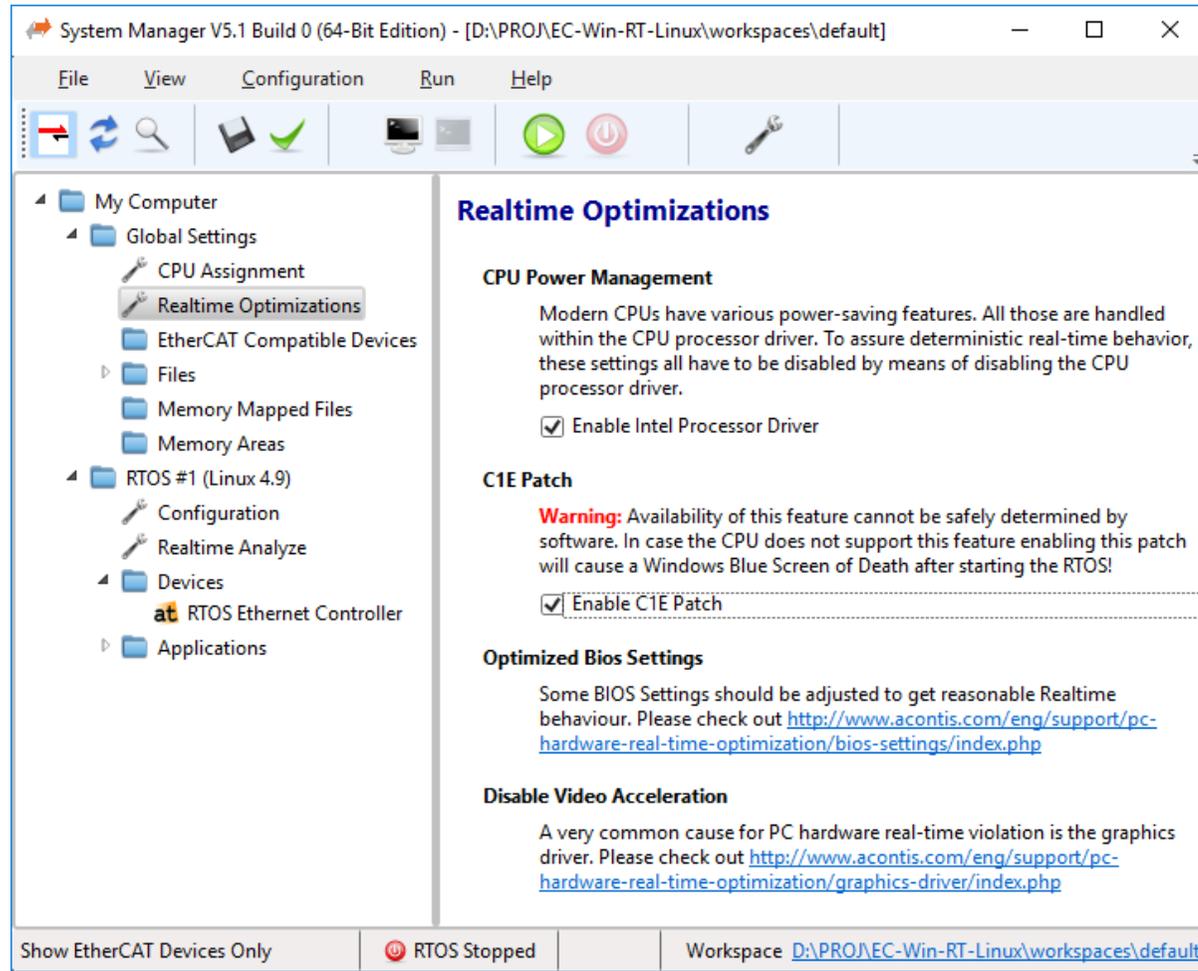
System Manager: Real-time analyzation (with optimization)



- Results

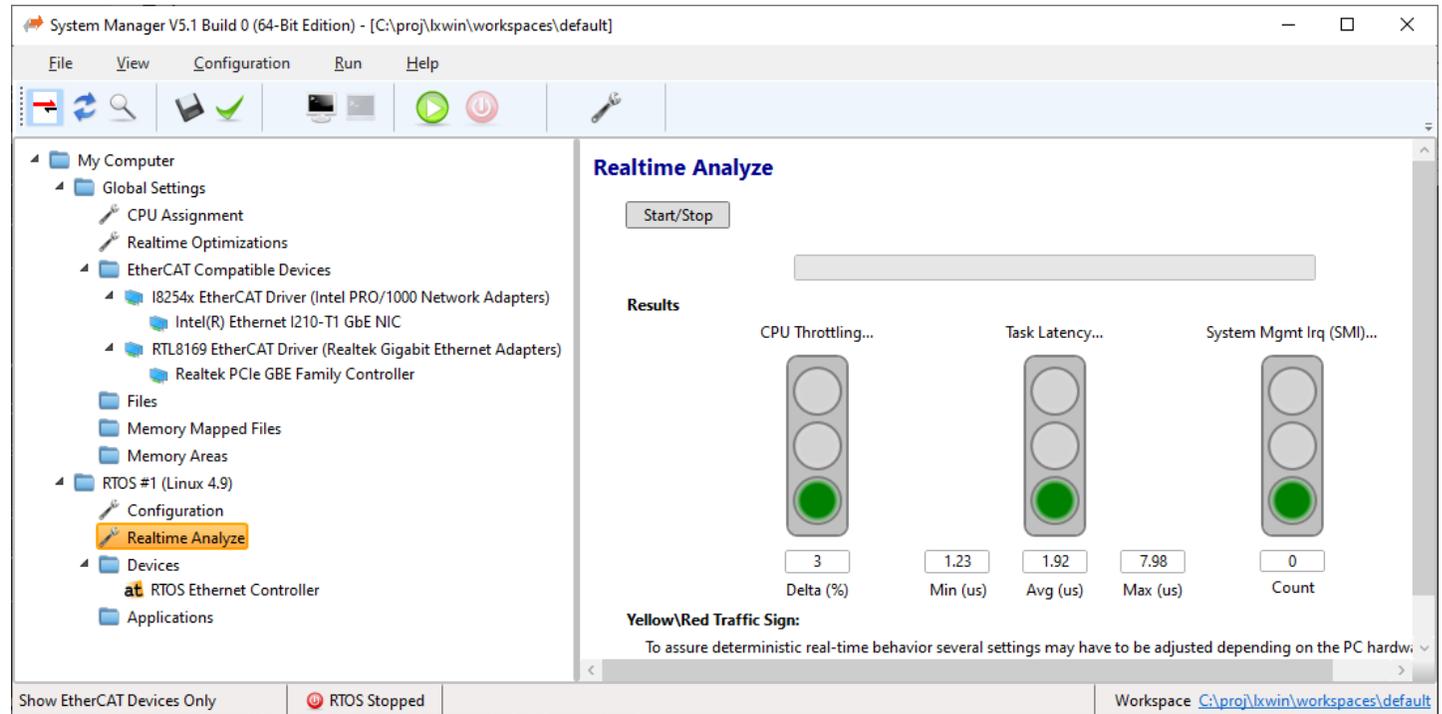
- CPU clock: throttling active?
- Timer: task level latency
- System Management Interrupts?

On non-optimized PCs real-time often cannot be guaranteed!



- Typical optimization steps
 - Disable CPU Power Management
 - Apply C1E Patch
 - BIOS settings (see hints on acontis website)
 - VGA Driver issue?

System Manager: Real-time analyzation (with optimization)



- Results

- CPU clock: no throttling
- Timer: short task level latency
- No SMIs

After applying one or multiple optimizations

→ most PCs will be able to run real-time applications!

LxWin[®]

Intel VT support

- Utilize more memory for Linux
 - Physical memory > 4GB can be used, even for 32 Bit Linux
 - Non-contiguous Windows Memory can be used
 - Example: 4 times 500 Mbyte Windows memory = 1 time 2 Gbyte Linux memory
- Support Shared Mode for Windows 64 Bit
 - Run Windows and Linux on the same physical core
- Better isolation: Fatal Linux kernel crash does not violate Windows
 - Exit into Virtual Monitor instead of system reboot
- Activate via configuration setting
 - Linux image and applications do not need to be changed

LxWin[®]

Quality Assurance

- Test lab to test products before a new version gets released
- More than 50 different PC's
 - some supplied by customers as reference systems
- A wide range of Intel and AMD processors
 - AMD: Athlon, Duron, Fusion etc.
 - Intel: Celeron/Pentium, Core i5/7, XEON, Atom etc.
- Different chipsets
 - Intel, Nvidia, VIA, SiS etc.
- Automated test scripts (e.g. ½ million start/stop cycles in one single test)

